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CLAIMS AMENDMENTS

Please amend claims 1, 3-5, 7-10, 12-19, 21-32, 34-40, 42, 44-45, 47-48, 51, 53-65, 67-70, 72-79, 81-92, 94-100, 102, 104-109, 111, 113-121. Please add new claims 122-200 All other claims remain unchanged.

1 1. (currently amended) A system for identifying ~~detecting~~ and
2 measuring concentrations of elements in fluids, comprising:
3 an ionic preconcentration cell, comprising:
4 an upper high surface area electrode comprising a high
5 specific surface area thereof;
6 a lower high surface area electrode comprising a high
7 specific surface area thereof, substantially parallel to
8 said upper high surface area electrode;
9 a central flow interelectrode gap separating said upper
10 and lower high surface area electrodes by a predetermined
11 interelectrode gap width; and
12 fluid flow means for flowing a fluid through said
13 central flow interelectrode gap; and
14 ~~—~~ calibration data associated with said cell
15 characterizing a response from said cell when said cell or an
16 equivalent cell is exposed to x-rays under calibration
17 conditions, used in combination with test data characterizing a
18 response from said cell when said cell is exposed to x-rays under
19 test conditions, to deduce ~~enabling an identity, or measurement~~
20 of concentration, of at least one element in said fluid ~~to be~~
21 ~~deduced.~~

1 2. (original) The system of claim 1, further comprising:

2 voltage application means for applying a voltage
3 differential between said upper high surface area electrode and
4 said lower high surface area electrode while said fluid is
5 flowing through said central flow interelectrode gap.

1 3. (currently amended) The system of claim 2, said voltage
2 application means further comprising:

3 a transportable voltage supply connected across said upper
4 and lower high surface area electrodes for applying an
5 electrostatic charge across said electrodes and thereby
6 maintaining ions from said at least one element entrained in said
7 electrodes during transport of said ionic preconcentration cell-
8 ~~supplying said voltage differential.~~

1 4. (currently amended) The system of claim 1, said ionic
2 preconcentration cell further comprising:

3 an upper x-ray transmission window in intimate contact with
4 an upper surface of said upper high surface area electrode.

1 5. (currently amended) The system of claim 4, said ionic
2 preconcentration cell further comprising:

3 a lower x-ray transmission window in intimate contact with a
4 lower surface of said lower high surface area electrode.

1 6. (original) The system of claim 1, said ionic
2 preconcentration cell further comprising:

3 inlet flow means for entering a fluid into said ionic
4 preconcentration cell and enabling said fluid to flow through
5 said central flow interelectrode gap.

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1 7. (currently amended) The system of claim 6, said inlet flow
2 means comprising at least one inlet flow slot substantially
3 coplanar with said central flow interelectrode gap.

1 8. (currently amended) The system of claim 6, said inlet flow
2 means comprising a plurality of inlet flow tubes substantially
3 coplanar with said central flow interelectrode gap and
4 substantially parallel with one another.

1 9. (currently amended) The system of claim 6, said inlet flow
2 means comprising turbulence enhancement means for enhancing a
3 turbulence of the flow of said fluid to induce mixing of said
4 flow to enable uniform extraction of said at least one element
5 from the flow stream.

1 10. (currently amended) The system of claim 6, said inlet
2 flow means comprising access ~~debris cleaning~~ means for accessing
3 said inlet flow means for cleaning debris therefrom ~~said inlet~~
4 ~~flow means.~~

1 11. (original) The system of claim 1, said ionic
2 preconcentration cell further comprising:
3 outlet flow means for exiting said fluid out from said ionic
4 preconcentration cell after said fluid has flowed through said
5 central flow interelectrode gap.

1 12. (currently amended) The system of claim 11, said outlet
2 flow means comprising at least one outlet flow slot substantially
3 coplanar with said central flow interelectrode gap.

1 13. (currently amended) The system of claim 11, said outlet
2 flow means comprising a plurality of outlet flow tubes_

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3 substantially coplanar with said central flow interelectrode gap
4 and substantially parallel with one another.

1 14. (currently amended) The system of claim 11, said outlet
2 flow means comprising access ~~debris cleaning~~ means for accessing
3 said inlet flow means for cleaning debris therefrom ~~said outlet~~
4 flow means.

1 15. (currently amended) The system of claim 4-1, said ionic
2 preconcentration cell further comprising:

3 a cell collector body maintaining a position of said upper
4 and lower high surface area electrodes and said upper x-ray
5 transmission window relative to one another, said cell collector
6 body in turn comprising a material comprising:

7 substantially no conductivity;

8 resistance to ionic leaching; and

9 resistance to radiation degradation from x-rays to

10 which said preconcentration cell is to be exposed.

1 16. (currently amended) The system of claim 4-1, said ionic
2 preconcentration cell further comprising:

3 a cell collector body maintaining a position of said upper
4 and lower high surface area electrodes and said upper x-ray
5 transmission window relative to one another, said cell collector
6 body comprising a material selected from a ~~the~~ material group
7 consisting of: plastic, glass, and fiberglass.

1 17. (currently amended) The system of claim 4-1, said ionic
2 preconcentration cell further comprising:

3 a cell collector body maintaining a position of said upper
4 and lower high surface area electrodes and said upper x-ray

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5 transmission window relative to one another, said cell collector
6 body comprising a non-conducting, machinable polymer
7 substantially resistant to radiation degradation~~Delrin® plastic.~~

1 18. (currently amended) The system of claim 1:

2 said upper high surface area electrode further comprising an
3 upper electrode thickness less than or equal to approximately $\ell =$
4 $1/(\mu * \rho)$, wherein:

5 ℓ designates ~~is~~ an optical depth of said upper high surface
6 area electrode when wetted with ~~in said fluid of a characteristic~~
7 ~~photonic energy from~~ an element of interest for which a fluidic
8 concentration is to be measured ~~by said system,~~ in said fluid;

9 μ designates ~~is~~ a mass absorption coefficient of said upper
10 high surface area electrode when wetted with said element of
11 interest in said fluid; and

12 ρ designates ~~is~~ a material density of said upper high
13 surface area electrode when wetted with said element of interest
14 in said fluid.

1 19. (currently amended) The system of claim 18:

2 said lower high surface area electrode further comprising an
3 upper electrode thickness less than or equal to approximately $\ell =$
4 $1/(\mu * \rho)$, wherein:

5 ℓ designates ~~is~~ an optical depth of said lower high surface
6 area electrode when wetted with ~~in said fluid of a characteristic~~
7 ~~photonic energy from~~ an element of interest for which a fluidic
8 concentration is to be measured ~~by said system,~~ in said fluid;

9 μ designates ~~is~~ a mass absorption coefficient of said lower

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10 high surface area electrode when wetted with said element of
 11 interest in said fluid; and
 12 ρ designates ~~is~~ a material density of said lower high
 13 surface area electrode when wetted with said element of interest
 14 in said fluid.

1 20. (original) The system of claim 1, said upper high surface
 2 area electrode and said lower high surface area electrode further
 3 comprising an ordinary surface area approximately equal to an
 4 interrogation spot area of x-rays to which said preconcentration
 5 cell is to be exposed.

1 21. (currently amended) The system of claim 4, said upper x-
 2 ray transmission window comprising a surface area approximately
 3 equal to an interrogation spot area of x-rays to which said
 4 preconcentration cell is to be exposed.

1 22. (currently amended) The system of claim 2, said central
 2 flow interelectrode gap comprising said predetermined
 3 interelectrode gap width, designated d , within an an interelectrode
 4 gap range specified by:

$$5 \quad d = \frac{\sigma \Phi w_i}{q \epsilon w_f n_f C F} \times 100\% \approx 2 \times 10^{-9} \frac{\Phi w_i A}{q \epsilon w_f n_f F} \times 100\% \propto \frac{\Phi A}{\epsilon F}, \text{ wherein:}$$

6 ϵ designates a predetermined percentage of at least one
 7 element of interest to be extracted from said fluid, σ designates
 8 a composite conductivity of said fluid, Φ designates a potential
 9 applied by said voltage application means across said electrodes,
 10 $q = 1.60 \times 10^{-19}$ Coulomb designates the unit charge, A designates an
 11 ordinary surface area covered by said electrodes, n_f designates a
 12 number density of said fluid, w_i and w_f designate atomic /

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13 | molecular weights, respectively, of said at least one element of
14 | interest and of said fluid, C designates a concentration of said
15 | at least one element of interest in said fluid, and F designates
16 | a flow rate of said fluid through said ionic preconcentration
17 | cell;

18 | said high surface area electrodes further comprise said
19 | ordinary surface area A approximately equal to an interrogation
20 | spot area of x-rays to which said preconcentration cell is to be
21 | exposed;

22 | said ε is chosen to be below approximately 5% for said at
23 | least one element of interest;

24 | said Φ is chosen to be below an electrochemical potential of
25 | said at least one element of interest and below an electrolysis
26 | potential of said fluid;

27 | said F is chosen to exert no more than approximately .1 atm
28 | of pressure upon an upper x-ray transmission window of said ionic
29 | preconcentration cell in intimate contact with an upper surface
30 | of said upper high surface area electrode;

31 | said n_f and said w_f are chosen with reference to said at
32 | least one element of interest; and

33 | said w_i is chosen with reference to said fluid.

1 | 23. (currently amended) The system of claim 22-1, said
2 | central flow interelectrode gap comprising said predetermined
3 | interelectrode gap width, ~~designated d~~ , with:

4 | a minimum gap width selected from a ~~the~~ minimum gap width
5 | group consisting of 2 mm, 1 mm, .5 mm, and .25 mm; and

6 | a maximum gap width selected from a ~~the~~ maximum gap width

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7 group consisting of 2 mm, 5 mm, and 10 mm.

1 24. (currently amended) The system of claim 4, said upper x-
2 ray transmission window comprising:

3 an atomic number below 10;

4 structural rigidity to support up to 1/10 atm. of pressure
5 without bowing more than approximately 100 microns;

6 substantial impermeability relative to said fluid;

7 x-ray transparency greater than 90% for characteristic
8 photon energies from an element of interest for which a fluidic
9 concentration is to be measured ~~by said system~~;

10 x-ray scattering therefrom minimized to less than

11 approximately 10% of radiation scattered from a column of said
12 fluid equal to one optical depth in said fluid of a

13 characteristic photonic energy from an element of interest for
14 which a fluidic concentration is to be measured ~~by said system~~;

15 and

16 freedom from any single contaminant in excess of 1 part per
17 million, when measured by x-ray fluorescence.

1 25. (currently amended) The system of claim 5, said lower x-
2 ray transmission window comprising:

3 an atomic number below 10;

4 structural rigidity to support up to 1/10 atm. of pressure
5 without bowing more than approximately 100 microns;

6 substantial impermeability relative to said fluid;

7 x-ray transparency greater than 90% for characteristic
8 photon energies from an element of interest for which a fluidic
9 concentration is to be measured ~~by said system~~;

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10 x-ray scattering therefrom minimized to less than
11 approximately 10% of radiation scattered from a column of said
12 fluid equal to one optical depth in said fluid of a
13 characteristic photonic energy from an element of interest for
14 which a fluidic concentration is to be measured ~~by said system;~~
15 and
16 freedom from any single contaminant in excess of 1 part per
17 million, when measured by x-ray fluorescence.

1 26. (currently amended) The system of claim 4, said upper x-
2 ray transmission window comprising a polyimide film comprising
3 structural rigidity to support up to 1/10 atm. of pressure
4 without bowing more than approximately 100 microns~~Kapton®~~.

1 27. (currently amended) The system of claim 5, said lower x-
2 ray transmission window comprising a polyimide film comprising
3 structural rigidity to support up to 1/10 atm. of pressure
4 without bowing more than approximately 100 microns~~Kapton®~~.

1 28. (currently amended) The system of claim 1:
2 said upper high surface area electrode and said lower high
3 surface area electrode each comprising a high surface area
4 material in turn comprising:
5 a large plurality of pores characterized by a specific
6 surface area of at least approximately 100 m²/g;
7 an average pore diameter of said pores between approximately
8 30 nm and 10 nm per pore;
9 a distribution of the said pore diameters grouped with a
10 standard deviation of less than approximately 10nm around said
11 average pore diameter;

an x-ray transparency greater than approximately 90% for characteristic photon energies from an element of interest for which a fluidic concentration is to be measured ~~by said system~~; electrical conductivity of 10-40 mOhms-cm when fabricated into a ¼ mm thick electrode;

the ability to contain approximately at least 0.1% by weight of foreign material relative to said high surface area material prior to saturation;

high structural rigidity wherein a displacement under the flow of said fluid does not exceed approximately 0.25mm;

high wetting ability wherein an approximately ¼ mm thick sheet of said high surface area material becomes substantially wetted in less than approximately three seconds; and

freedom from metallic impurities in excess of approximately .5 parts per million, when measured by x-ray fluorescence XRF analysis.

29. (currently amended) The system of claim 28, said large plurality of pores characterized by a specific surface area of at least approximately 400 m²/g.

30. (currently amended) The system of claim 28, said large plurality of pores characterized by a specific surface area of at most approximately 1000 m²/g.

31. (currently amended) The system of claim 29, said large plurality of pores characterized by a specific surface area of at most approximately 1000 m²/g.

32. (currently amended) The system of claim 1, said upper high surface area electrode and said lower high surface area electrode

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each comprising a high surface area material in turn comprising:
an x-ray transparency greater than approximately 90% for
characteristic photon energies from an element of interest for
which a fluidic concentration is to be measured—~~nanocellular~~
carbon.

33. (original) The system of claim 1, said upper high surface area electrode and said lower high surface area electrode each comprising a carbon aerogel.

34. (currently amended) The system of claim 1, said upper high surface area electrode comprising a thickness less than approximately $\ell = 1/(\mu * \rho)$; wherein:

ℓ designates an optical depth of said upper high surface area electrode when wetted with said fluid;

μ designates a mass absorption coefficient of said high surface area electrode when wetted with said fluid; and

ρ designates a density of said high surface area electrode when wetted with said fluid.

35. (currently amended) The system of claim 34, said lower high surface area electrode comprising a thickness less than
approximately $\ell = 1/(\mu * \rho)$; wherein:

ℓ designates an optical depth of said lower high surface area electrode when wetted with said fluid;

μ designates a mass absorption coefficient of said lower surface area electrode when wetted with said fluid; and

8 p designates a density of said lower surface area electrode
9 when wetted with said fluid. ~~matching said thickness of said~~
10 ~~upper high surface area electrode by approximately \pm 10%.~~

1 36. (currently amended) The system of claim 1, said
2 calibration data comprising: ~~ionic preconcentration cell further~~
3 ~~comprising background data associated therewith.~~
4 ~~said background data comprising data related to a rate at~~
5 which photons are detected to be emitted from at least one
6 background data energy channel of said preconcentration cell or
7 an equivalent cell, when said preconcentration cell or equivalent
8 cell is filled with a highly purified form of a fluid of interest
9 and exposed to x-rays.

1 37. (currently amended) The system of claim 1, said
2 calibration data further comprising: ~~ionic preconcentration cell~~
3 ~~further comprising sensitivity data associated therewith.~~
4 ~~said sensitivity data comprising data related to a rate at~~
5 which photons are detected to be emitted from at least one
6 sensitivity data energy channel of said preconcentration cell or
7 an equivalent cell, when said preconcentration cell or equivalent
8 cell is filled with a first calibration solution, containing at
9 least one element of interest in a said fluid of interest in
10 known concentration above a minimum detection level of x-ray
11 detection equipment to be used for said detecting and measuring,
12 and when said preconcentration cell or equivalent cell is exposed
13 to x-rays.

1 38. (currently amended) The system of claim 2, said
2 calibration data further comprising: ~~ionic preconcentration cell~~

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3 ~~further comprising ion extraction rate data acquired from and~~
4 ~~associated therewith:~~

5 ~~said~~ ion extraction rate data ~~comprising data~~ related to a
6 rate at which photons are detected to be emitted from ~~said~~ at
7 least one ion extraction rate data energy channel of said
8 preconcentration cell or an equivalent cell, when a ~~second~~
9 calibration solution, containing said at least one element of
10 interest in a ~~said~~ fluid of interest in known concentration below
11 a ~~said~~ minimum detection level of x-ray detection equipment to be
12 used for said detecting and measuring, is flowed through the said
13 central flow interelectrode gap of said preconcentration cell or
14 equivalent cell, at a substantially constant flow rate, while the
15 ~~said~~ voltage application means applies the said voltage
16 differential across the said electrodes of said preconcentration
17 cell or equivalent cell, below an electrochemical potential of
18 said at least one element of interest and below an electrolysis
19 potential of said second calibration solution, and when said
20 preconcentration cell or equivalent cell is exposed to x-rays.

1 39. (currently amended) The system of claim 2, said
2 calibration data further comprising: ~~ionic preconcentration cell~~
3 ~~further comprising background data, sensitivity data, and ion~~
4 ~~extraction rate data acquired from and associated therewith:~~

5 ~~said~~ background data ~~comprising data~~ related to a rate at
6 which photons are detected to be emitted from at least one
7 background data energy channel of said preconcentration cell or
8 an equivalent cell, when said preconcentration cell or equivalent
9 cell is filled with a highly purified form of a fluid of interest

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10 and exposed to x-rays;

11 ~~said~~ sensitivity data ~~comprising data~~ related to a rate at
12 which photons are detected to be emitted from at least one
13 sensitivity data energy channel of said preconcentration cell or
14 equivalent cell, when said preconcentration cell or equivalent
15 cell is filled with a first calibration solution, containing at
16 least one element of interest in said fluid of interest in known
17 concentration above a minimum detection level of x-ray detection
18 equipment to be used for said detecting and measuring, and when
19 said preconcentration cell or equivalent cell is exposed to x-
20 rays; and

21 ~~said~~ ion extraction rate data ~~comprising data~~ related to a
22 rate at which photons are detected to be emitted from ~~said~~ at
23 least one ion extraction rate data energy channel of said
24 preconcentration cell or an equivalent cell, when a second
25 calibration solution, containing said at least one element of
26 interest in said fluid of interest in known concentration below
27 said minimum detection level of x-ray detection equipment to be
28 used for said detecting and measuring, is flowed through the said
29 central flow interelectrode gap of said preconcentration cell or
30 equivalent cell, at a substantially constant flow rate, while the
31 ~~said~~ voltage application means applies the said voltage
32 differential across the said electrodes of said preconcentration
33 cell or equivalent cell, below an electrochemical potential of
34 said at least one element of interest and below an electrolysis
35 potential of said second calibration solution, and when said
36 preconcentration cell or equivalent cell is exposed to x-rays.

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1 40. (currently amended) The system of claim 2, further
2 comprising:
3 test data accumulation means for obtaining said test data
4 comprising data related to a rate at which photons are detected
5 to be emitted from ~~said~~ at least one energy channel of said
6 preconcentration cell when said fluid, suspected to contain at
7 least one element of interest, is flowed through said central
8 flow interelectrode gap at a substantially constant flow rate,
9 while said voltage application means applies said voltage
10 differential across said electrodes below an electrochemical
11 potential of said at least one element of interest and below an
12 electrolysis potential of said fluid, and when said
13 preconcentration cell is exposed to x-rays.

1 41. (original) The system of claim 40, further comprising:
2 analysis means for analyzing said test data and deducing
3 therefrom a concentration in said fluid, if any, of the suspected
4 at least one element of interest.

1 42. (currently amended) The system of claim 39, further
2 comprising:
3 test data accumulation means for obtaining said test data
4 comprising data related to a rate at which photons are detected
5 to be emitted from ~~said~~ at least one energy channel of said
6 preconcentration cell when said fluid, suspected to contain at
7 least one element of interest, is flowed through said central
8 flow interelectrode gap at a substantially constant flow rate,
9 while said voltage application means applies said voltage
10 differential across said electrodes below an electrochemical

11 potential of said at least one element of interest and below an
12 electrolysis potential of said fluid, and when said
13 preconcentration cell is exposed to x-rays.

1 43. (original) The system of claim 42, further comprising:
2 analysis means for analyzing said test data in relation to
3 said background data, said sensitivity data, and said ion
4 extraction rate data, and deducing therefrom a concentration in
5 said fluid, if any, of the suspected at least one element of
6 interest.

1 44. (currently amended) The system of claim 4-2, further
2 comprising:
3 voltage application means for applying a voltage
4 differential between said upper high surface area electrode and
5 said lower high surface area electrode while said fluid is
6 flowing through said central flow interelectrode gap; and
7 x-ray source means positioned and aligned relative to said
8 upper x-ray transmission window for exposing said
9 preconcentration cell to x-rays substantially transmitted through
10 said upper x-ray transmission window, while flowing said fluid
11 and while applying said voltage differential.

1 45. (currently amended) The system of claim 2, said voltage
2 application means further comprising:
3 a transportable voltage supply for applying an electrostatic
4 charge across said electrodes and thereby maintaining ions from
5 said at least one element entrained in said electrodes during
6 transport of said ionic preconcentration cell ~~for continuing to~~
7 ~~apply said voltage differential:~~ after ceasing flow of flowing

8 said fluid, while transporting said ionic preconcentration cell
 9 to an x-ray source means for emitting x-rays toward said
 10 preconcentration cell, and while exposing said preconcentration
 11 cell to x-rays.

1 46. (original) The system of claim 1, further comprising:
 2 flow control means for controlling a flow rate of said fluid
 3 through said ionic preconcentration cell so as to maintain ε ,
 4 which designates a predetermined percentage of at least one
 5 element of interest to be extracted from said fluid, below
 6 approximately 5% for said at least one element of interest.

1 47. (currently amended) The system of claim 46, wherein said
 2 ε is maintained below an extraction percentage selected from an
 3 ~~the~~ extraction percentage group consisting of approximately 4%,
 4 3%, 2%, and 1%.

1 48. (currently amended) The system of claim 2, further
 2 comprising flow control means for:
 3 controlling a flow rate F of said fluid through said ionic
 4 preconcentration cell and maintaining said F at a substantially
 5 constant level so as to maintain ε , which designates a
 6 predetermined percentage of at least one element of interest to
 7 be extracted from said fluid and is specified by:

$$8 \quad \varepsilon = \frac{\Gamma_{ie}}{\Gamma_{is}} = \frac{\sigma \Phi w_i}{qd w_f n_f CF} \times 100\%,$$

9 below approximately 5% for said at least one element of interest;
 10 wherein:

11 Γ_{ie} and Γ_{is} designate rates at which ions of said at least
 12 one element of interest are respectively extracted from said

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13 fluid by said cell and supplied to said cell by said fluid, σ
14 designates a composite conductivity of said fluid, Φ designates
15 a potential applied by said voltage application means across said
16 electrodes, d designates said predetermined interelectrode gap
17 width of said central flow interelectrode gap, $q = 1.60 \times 10^{-19}$
18 Coulomb designates the unit charge, A designates an ordinary
19 surface area covered by said electrodes, n_f designates a number
20 density of said fluid, w_i and w_f designate atomic / molecular
21 weights, respectively, of said at least one element of interest
22 and of said fluid, and C designates a concentration of said at
23 least one element of interest in said fluid; and

24 | for having said concentration C in a range where
25 | conductivity varies substantially linearly with concentration,
26 | with C in units of parts per billion, wherein σ is approximated
27 | by:

28 $\sigma \approx 2 \times 10^{-9} C / \text{Ohm} - \text{cm} .$

1 49. (original) The system of claim 48, wherein said ε is
2 maintained below an extraction percentage selected from the
3 extraction percentage group consisting of approximately 4%, 3%,
4 2% and 1%.

1 50. (original) The system of claim 2, said voltage
2 application means applying said voltage differential across said
3 electrodes below an electrochemical potential of at least one
4 element of interest and below an electrolysis potential of said
5 fluid.

1 51. (currently amended) The system of claim 1, further
2 comprising:

3 leakage current monitoring means for monitoring a total
4 concentration of dissolved ions in said upper and lower high
5 surface area electrodes while said electrodes are not saturated,
6 ~~detecting a saturation state of said cell by~~ monitoring a leakage
7 current from said cell.

1 52. (original) The system of claim 51, further comprising:

2 ultra-low trace measuring means for measuring at least one
3 element of interest comprising ultra-low trace, high valence ions
4 in said fluid, based on said detecting said saturation state.

1 53. (currently amended) The system of claim 1, further
2 comprising:

3 leakage current monitoring means for monitoring a total
4 concentration of dissolved ions in said upper and lower high
5 surface area electrodes while said electrodes are not saturated-
6 ~~estimating a concentration in said fluid of at least one element~~
7 ~~of interest by monitoring a leakage current in said cell; and~~
8 flow rate adjustment time control means for adjusting the
9 flow of said fluid controlling how long said fluid flows through
10 said ionic preconcentration cell to control a percentage of said
11 ions extracted from said fluid, based on said monitoring said
12 leakage current ~~the estimate obtained by said leakage current~~
13 monitoring means.

1 54. (currently amended) The system of claim 1, further
2 comprising:

3 time control means for controlling how long said fluid flows

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4 through said ionic preconcentration cell based on setting an
5 impurity concentration C , in a range where conductivity varies
6 substantially linearly with concentration, to a predetermined
7 desired concentration detection level and flowing said fluid for
8 a time t given by:

9
$$t \propto \frac{Sl}{\sigma} \propto \frac{Sl}{C}; \text{ wherein:}$$

10 S designates a sensitivity of x-ray detection equipment to
11 be used for said detecting and measuring;

12 l designates a thickness of said upper high surface area
13 electrode; and

14 σ designates a composite conductivity of said fluid.

1 55. (currently amended) The system of claim 1, further
2 comprising triggering means for triggering an action in response
3 to when said system detects that a concentration of at least
4 one element of interest in said fluid has passed a predetermined
5 threshold concentration.

1 56. (currently amended) The system of claim 55, further
2 comprising injection action means for injecting at least one
3 element into said fluid, thereby maintaining said concentration
4 within a predetermined concentration range, as said action in
5 response to said triggering means.

1 57. (currently amended) The system of claim 55, further
2 comprising dilution action means for diluting at least one
3 diluting fluid into said fluid, thereby maintaining said
4 concentration within a predetermined concentration range, as said
5 action in response to said triggering means.

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1 58. (currently amended) The system of claim 1, further
2 comprising:
3 ionic release means for cleaning said preconcentration cell
4 after use by releasing ~~said~~ ions accumulated within said high
5 specific surface area of said electrodes into said fluid, after
6 the accumulated ions have been exposed to x-rays and fluorescence
7 from said preconcentration cell has been detected.

1 59. (currently amended) The system of claim 4-1, further
2 comprising:
3 x-ray source means positioned and aligned relative to said
4 upper x-ray transmission window for emitting x-rays toward said
5 preconcentration cell substantially transmitted through said
6 upper x-ray transmission window; and
7 x-ray fluorescence detector means positioned and aligned
8 relative to said upper x-ray transmission window for detecting
9 fluoresced energy emitted by said preconcentration cell due to
10 said emitting ~~said~~ x-rays toward said preconcentration cell,
11 through said upper x-ray transmission window.

1 60. (currently amended) The system of claim 59, further
2 comprising:
3 x-ray fluorescence analysis means for analyzing the detected
4 x-ray fluoresced energy and deducing therefrom a concentration in
5 said fluid of at least one element of interest in said fluid.

1 61. (currently amended) The system of claim 1, further
2 comprising:

3 ~~telecommunications control means for controlling an~~
4 ~~operation of said ionic preconcentration cell using a~~

data from said ionic preconcentration cell.

62. (currently amended) A method for identifying detecting
and measuring concentrations of elements in fluids, comprising
the steps of:

flowing a fluid through a central flow interelectrode gap of
an ionic preconcentration cell separating an upper high specific
surface area electrode from a lower high specific surface area
electrode of said ionic preconcentration cell by a predetermined
interelectrode gap width;

applying a voltage differential between said upper high
surface area electrode and said lower high surface area electrode
while said fluid is flowing through said central flow

interelectrode gap;

exposing said cell to x-rays under test conditions and
obtaining test data characterizing a response thereto of said
cell; and

deducing an identity, or measurement of concentration, of at
least one element in said fluid, using said test data in
combination with calibration data associated with said cell
characterizing a response from said cell when said cell or an
equivalent cell is exposed to x-rays under calibration
conditions.

63. (currently amended) The method of claim 62, said step of
applying said voltage differential further comprising the step
of:

applying an electrostatic charge across said electrodes and

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5 thereby maintaining ions from said at least one element entrained
6 in said electrodes during transport of said ionic
7 preconcentration cell, supplying said voltage differential using
8 a transportable voltage supply.

1 64. (currently amended) The method of claim 62, further
2 comprising the step of:

3 intimately contacting an upper surface of said upper high
4 surface area electrode with an upper x-ray transmission window of
5 said ionic preconcentration cell.

1 65. (currently amended) The method of claim 64, further
2 comprising the step of:

3 intimately contacting a lower surface of said lower high
4 surface area electrode with a lower x-ray transmission window of
5 said ionic preconcentration cell.

1 66. (original). The method of claim 62, further comprising the
2 steps of:

3 entering a fluid into said ionic preconcentration cell using
4 inlet flow means therefor; and

5 enabling said fluid to flow through said central flow
6 interelectrode gap.

1 67. (currently amended) The method of claim 66, said step of
2 entering said fluid further comprising entering said fluid
3 through said inlet flow means comprising at least one inlet flow
4 slot substantially coplanar with said central flow interelectrode
5 gap.

1 68. (currently amended) The method of claim 66, said step of
2 entering said fluid further comprising entering said fluid

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3 through said inlet flow means comprising a plurality of inlet
4 flow tubes substantially coplanar with said central flow
5 interelectrode gap and substantially parallel with one another.

1 69. (currently amended) The method of claim 66, further
2 comprising the step of enhancing a turbulence of the flow of said
3 fluid while entering said fluid, thereby inducing mixing of said
4 flow for enabling uniform extraction of said at least one element
5 from the flow stream.

1 70. (currently amended) The method of claim 66, further
2 comprising the step of cleaning debris from said inlet flow means
3 using access ~~debris cleaning~~ means therefor accessing said inlet
4 flow means.

1 71. (original) The method of claim 62, further comprising the
2 step of:

3 exiting said fluid out from said ionic preconcentration cell
4 after said fluid has flowed through said central flow
5 interelectrode gap using outlet flow means therefor.

1 72. (currently amended) The method of claim 71, said step of
2 exiting said fluid further comprising exiting said fluid through
3 said outlet flow means comprising at least one outlet flow slot_
4 substantially coplanar with said central flow interelectrode gap.

1 73. (currently amended) The method of claim 71, said step of
2 exiting said fluid further comprising exiting said fluid through
3 said outlet flow means comprising a plurality of outlet flow
4 tubes substantially coplanar with said central flow
5 interelectrode gap and substantially parallel with one another.

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1 74. (currently amended) The method of claim 71, further
2 comprising the step of cleaning debris from said outlet flow
3 means using access debris cleaning means therefor accessing said
4 inlet flow means.

1 75. (currently amended) The method of claim 64-62, further
2 comprising the step of:
3 maintaining a position of said upper and lower high surface
4 area electrodes and said upper x-ray transmission window relative
5 to one another, using ~~embodying~~ a body of said ionic
6 preconcentration cell comprising ~~in~~ a material comprising:
7 substantially no conductivity;
8 resistance to ionic leaching; and
9 resistance to radiation degradation from x-rays to
10 which said preconcentration cell is to be exposed.

1 76. (currently amended) The method of claim 64-62, further
2 comprising the step of:
3 maintaining a position of said upper and lower high surface
4 area electrodes and said upper x-ray transmission window relative
5 to one another, using ~~embodying~~ a body of said ionic
6 preconcentration cell comprising ~~in~~ a material selected from a
7 ~~the~~ material group consisting of: plastic, glass, and fiberglass.

1 77. (currently amended) The method of claim 64-62, further
2 comprising the step of:
3 maintaining a position of said upper and lower high surface
4 area electrodes and said upper x-ray transmission window relative
5 to one another, using ~~embodying~~ a body of said ionic
6 preconcentration cell comprising ~~in~~ a material comprising a non-

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conducting, machinable polymer substantially resistant to
radiation degradation ~~Delrin®~~ plastic.

78. (currently amended) The method of claim 62, further
comprising the step of:

providing said upper high surface area electrode with an
upper electrode thickness thereof less than or equal to
approximately $\ell = 1/(\mu * \rho)$, wherein:

ℓ designates ~~is~~ an optical depth of said upper high surface
area electrode when wetted with ~~in said fluid of a characteristic~~
~~photonic energy from~~ an element of interest for which a fluidic
concentration is to be measured ~~by said method~~, in said fluid;

μ designates ~~is~~ a mass absorption coefficient of said upper
high surface area electrode, when wetted with said element of
interest in said fluid; and

ρ designates ~~is~~ a material density of said upper high
surface area electrode, when wetted with said element of interest
in said fluid.

79. (currently amended) The method of claim 78, further
comprising the step of:

providing said lower high surface area electrode with a
lower electrode thickness thereof less than or equal to
approximately $\ell = 1/(\mu * \rho)$, wherein:

ℓ designates ~~is~~ an optical depth of said lower high surface
area electrode when wetted with ~~in said fluid of a characteristic~~
~~photonic energy from~~ an element of interest for which a fluidic
concentration is to be measured ~~by said method~~, in said fluid;

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μ designates is a mass absorption coefficient of said lower high surface area electrode, when wetted with said element of interest in said fluid; and

ρ designates is a material density of said lower high surface area electrode, when wetted with said element of interest in said fluid.

80. (original) The method of claim 62, further comprising the step of:

providing ordinary surface areas of said upper high surface area electrode and said lower high surface area electrode approximately equal to an interrogation spot area of x-rays to which said preconcentration cell is to be exposed.

81. (currently amended) The method of claim 64, further comprising the step of:

providing a surface area of said upper x-ray transmission window approximately equal to an interrogation spot area of x-rays to which said preconcentration cell is to be exposed.

82. (currently amended) The method of claim 62, further comprising the step of:

providing said central flow interelectrode gap comprising said predetermined interelectrode gap width, designated d , within an interelectrode gap range specified by:

$$d = \frac{\sigma \Phi w_i}{q \epsilon w_f n_f C F} \times 100\% \approx 2 \times 10^{-9} \frac{\Phi w_i A}{q \epsilon w_f n_f F} \times 100\% \propto \frac{\Phi A}{\epsilon F}; \text{ wherein:}$$

ϵ designates a predetermined percentage of at least one element of interest to be extracted from said fluid, σ designates

11 "Coulomb designates the unit charge, A designates an ordinary
12 surface area covered by said electrodes, n_f designates a number
13 density of said fluid, w_i and w_f designate atomic / molecular
14 weights, respectively, of said at least one element of interest
15 and of said fluid, C designates a concentration of said at least
16 one element of interest in said fluid, and F designates a flow
17 rate of said fluid through said ionic preconcentration cell;

18 said high surface area electrodes further comprise said
19 ordinary surface area A approximately equal to an interrogation
20 spot area of x-rays to which said preconcentration cell is to be
21 exposed;

22 said ε is chosen to be below approximately 5% for said at
23 least one element of interest;

24 said Φ is chosen to be below an electrochemical potential of
25 said at least one element of interest and below an electrolysis
26 potential of said fluid;

27 said F is chosen to exert no more than approximately .1 atm
28 of pressure upon an upper x-ray transmission window of said ionic
29 preconcentration cell in intimate contact with an upper surface
30 of said upper high surface area electrode;

31 said n_f and said w_f are chosen with reference to said at
32 least one element of interest; and

33 said w_i is chosen with reference to said fluid.

1 83. (currently amended) The method of claim_82-62, further
2 comprising the step of:

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3 providing said central flow interelectrode gap comprising
4 said predetermined interelectrode gap width, ~~designated d~~, with:
5 a minimum gap width selected from a ~~the~~ minimum gap width
6 group consisting of 2 mm, 1 mm, .5 mm, and .25 mm; and
7 a maximum gap width selected from a ~~the~~ maximum gap width
8 group consisting of 2 mm, 5 mm, and 10 mm.

1 84. (currently amended) The method of claim 64, further
2 comprising the step of providing said upper x-ray transmission
3 window comprising:

4 an atomic number below 10;
5 structural rigidity to support up to 1/10 atm. of pressure
6 without bowing more than approximately 100 microns;

7 substantial impermeability relative to said fluid;
8 x-ray transparency greater than 90% for characteristic
9 photon energies from an element of interest for which a fluidic
10 concentration is to be measured ~~by said method~~;

11 x-ray scattering therefrom minimized to less than
12 approximately 10% of radiation scattered from a column of said
13 fluid equal to one optical depth in said fluid of a
14 characteristic photonic energy from an element of interest for
15 which a fluidic concentration is to be measured ~~by said method~~;
16 and

17 freedom from any single contaminant in excess of 1 part per
18 million, when measured by x-ray fluorescence.

1 85. (currently amended) The method of claim 65, further
2 comprising the step of providing said lower x-ray transmission
3 window comprising:

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4 an atomic number below 10;
5 structural rigidity to support up to 1/10 atm. of pressure
6 without bowing more than approximately 100 microns;
7 substantial impermeability relative to said fluid;
8 x-ray transparency greater than 90% for characteristic
9 photon energies from an element of interest for which a fluidic
10 concentration is to be measured ~~by said method~~;
11 x-ray scattering therefrom minimized to less than
12 approximately 10% of radiation scattered from a column of said
13 fluid equal to one optical depth in said fluid of a
14 characteristic photonic energy from an element of interest for
15 which a fluidic concentration is to be measured ~~by said method~~;
16 and
17 freedom from any single contaminant in excess of 1 part per
18 million, when measured by x-ray fluorescence.

1 86. (currently amended) The method of claim 64, further
2 comprising the step of:

3 providing said upper x-ray transmission window comprising a
4 polyimide film comprising structural rigidity to support up to
5 1/10 atm. of pressure without bowing more than approximately 100
6 microns ~~Kapton®~~.

1 87. (currently amended) The method of claim 65, further
2 comprising the step of:

3 providing said lower x-ray transmission window comprising a
4 polyimide film comprising structural rigidity to support up to
5 1/10 atm. of pressure without bowing more than approximately 100
6 microns ~~Kapton®~~.

1 88. (currently amended) The method of claim 62 further
2 comprising the step of:
3 providing said upper high surface area electrode and said
4 lower high surface area electrode each comprising a high surface
5 area material in turn comprising:
6 a large plurality of pores characterized by a specific
7 surface area of at least approximately 100 m²/g;
8 an average pore diameter of said pores between approximately
9 30 nm and 10 nm per pore;
10 a distribution of the said pore diameters grouped with a
11 standard deviation of less than approximately 10nm around said
12 average pore diameter;
13 an x-ray transparency greater than approximately 90% for
14 characteristic photon energies from an element of interest for
15 which a fluidic concentration is to be measured ~~by said method~~;
16 electrical conductivity of 10-40 mOhms-cm when fabricated
17 into a ¼ mm thick electrode;
18 the ability to contain approximately at least 0.1% by weight
19 of foreign material relative to said high surface area material
20 prior to saturation;
21 high structural rigidity wherein a displacement under the
22 flow of said fluid does not exceed approximately 0.25mm;
23 high wetting ability wherein an approximately ¼ mm thick
24 sheet of said high surface area material becomes substantially
25 wetted in less than approximately three seconds; and
26 freedom from metallic impurities in excess of approximately
27 .5 parts per million, when measured by x-ray fluorescence XRF

20 analysis.

1 89. (currently amended) The method of claim 88, said large
2 plurality of pores characterized by a specific surface area of at
3 least approximately 400 m²/g..

1 90. (currently amended) The method of claim 88, said large
2 plurality of pores characterized by a specific surface area of at
3 most approximately 1000 m²/g.

1 91. (currently amended) The method of claim 89, said large
2 plurality of pores characterized by a specific surface area of at
3 most approximately 1000 m²/g.

1 92. (currently amended) The method of claim 62, further
2 comprising the step of:

3 providing said upper high surface area electrode and said
4 lower high surface area electrode each comprising a high surface
5 area material in turn comprising:

6 an x-ray transparency greater than approximately 90% for
7 characteristic photon energies from an element of interest for
8 which a fluidic concentration is to be measured~~nano-cellular~~
9 ~~carbon.~~

1 93. (original) The method of claim 62, further comprising the
2 step of:

3 providing said upper high surface area electrode and said
4 lower high surface area electrode each comprising a carbon
5 aerogel.

1 94. (currently amended) The method of claim 62, further
2 comprising the step of:

3 providing said upper high surface area electrode with a

5 ℓ designates an optical depth of said upper high surface
6 area electrode when wetted with said fluid;

7 μ designates a mass absorption coefficient of said high
8 surface area electrode when wetted with said fluid; and

9 ρ designates a density of said high surface area electrode
10 when wetted with said fluid.

1 95. (currently amended) The method of claim 94, further
2 comprising the step of:

3 providing said lower high surface area electrode with a
4 thickness less than approximately $\ell = 1/(\mu \cdot \rho)$; wherein:

5 ℓ designates an optical depth of said lower high surface
6 area electrode when wetted with said fluid;

7 μ designates a mass absorption coefficient of said lower
8 surface area electrode when wetted with said fluid; and

9 ρ designates a density of said lower surface area electrode
10 when wetted with said fluid.

11 ~~matching said thickness of said upper high surface area~~
12 ~~electrode by approximately $\pm 10\%$.~~

1 96. (currently amended) The method of claim 62, further
2 comprising the step of obtaining said calibration data by:-

3 ~~acquiring background data from said ionic preconcentration cell~~
4 ~~and associating said data therewith.~~

5 ~~said step of acquiring said background data comprising the~~
6 ~~steps of:~~

7 ~~—filling said preconcentration cell or an equivalent~~

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8 cell, with a highly purified form of a fluid of interest;
9 —exposing the filled ~~said~~ preconcentration cell or
10 equivalent cell to x-rays; ~~and~~
11 —acquiring ~~said~~ background data related to a rate at
12 which photons are detected to be emitted from at least one
13 background data energy channel of said preconcentration cell or
14 equivalent cell; and
15 —associating said background data with said preconcentration
16 cell.

1 97. (currently amended) The method of claim 62, further
2 comprising the step of obtaining said calibration data by:-
3 ~~acquiring sensitivity data from said ionic preconcentration cell~~
4 ~~and associating said data therewith.~~
5 ~~—said step of acquiring said sensitivity data comprising the~~
6 ~~steps of:-~~
7 —filling said preconcentration cell or an equivalent
8 cell, with a first calibration solution containing at least one
9 element of interest in a ~~said~~ fluid of interest in known
10 concentration above a minimum detection level of x-ray detection
11 equipment to be used for said detecting and measuring;
12 —exposing the filled ~~said~~ preconcentration cell or
13 equivalent cell to x-rays; ~~and~~
14 —acquiring ~~said~~ sensitivity data related to a rate at
15 which photons are detected to be emitted from at least one
16 sensitivity data energy channel of said preconcentration cell or
17 equivalent cell; and
18 —associating said sensitivity data with said preconcentration

~~comprising the step of obtaining said calibration data by:~~
acquiring ion extraction rate data from said ionic
preconcentration cell and associating said data therewith;
~~— said step of acquiring said ion extraction rate data~~
~~comprising the steps of:~~
— applying said voltage differential across the said
electrodes of said preconcentration cell or an equivalent cell,
below an electrochemical potential of said at least one element
of interest and below an electrolysis potential of a said second
calibration solution;
— flowing said a second calibration solution containing
said at least one element of interest in a said fluid of interest
in known concentration below a said minimum detection level of x-
ray detection equipment to be used for said detecting and
measuring through the said central flow interelectrode gap of
said preconcentration cell or equivalent cell at a substantially
constant flow rate;
— exposing said preconcentration cell or equivalent cell
with said ~~second~~ calibration solution therein to x-rays; ~~and~~
— acquiring ~~said~~ ion extraction rate data related to a
rate at which photons are detected to be emitted from ~~said~~ at
least one ion extraction rate data energy channel of said
preconcentration cell or equivalent cell; and
associating said ion extraction rate data with said
preconcentration cell.

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19 | cell.

1 | 98. (currently amended) The method of claim 62, further
2 | comprising the step of obtaining said calibration data by:-
3 | ~~acquiring ion extraction rate data from said ionic~~
4 | ~~preconcentration cell and associating said data therewith;~~
5 | ~~— said step of acquiring said ion extraction rate data~~
6 | ~~comprising the steps of:~~
7 | ~~— applying said voltage differential across the said~~
8 | ~~electrodes of said preconcentration cell or an equivalent cell,~~
9 | below an electrochemical potential of said at least one element
10 | of interest and below an electrolysis potential of a said second
11 | calibration solution;

12 | ~~— flowing said a second calibration solution containing~~
13 | said at least one element of interest in a said fluid of interest
14 | in known concentration below a said minimum detection level of x-
15 | ray detection equipment to be used for said detecting and
16 | measuring through the said central flow interelectrode gap of
17 | said preconcentration cell or equivalent cell at a substantially
18 | constant flow rate;

19 | ~~— exposing said preconcentration cell or equivalent cell~~
20 | with said ~~second~~ calibration solution therein to x-rays; ~~and~~

21 | ~~— acquiring said ion extraction rate data related to a~~
22 | rate at which photons are detected to be emitted from ~~said~~ at
23 | least one ion extraction rate data energy channel of said
24 | preconcentration cell or equivalent cell; and

25 | associating said ion extraction rate data with said
26 | preconcentration cell.

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1 99. (currently amended) The method of claim 62, further
2 comprising the steps of obtaining said calibration data by:-
3 ~~acquiring background data, sensitivity data, and ion extraction~~
4 ~~rate data from said ionic preconcentration cell and associating~~
5 ~~said data therewith:-~~
6 ~~—— said step of acquiring said background data comprising the~~
7 ~~steps of:-~~
8 ~~—— filling said preconcentration cell or an equivalent~~
9 ~~cell, with a highly purified form of a fluid of interest;~~
10 ~~—— exposing the filled ~~said~~ preconcentration cell or~~
11 ~~equivalent cell to x-rays;—and~~
12 ~~—— acquiring ~~said~~ background data related to a rate at~~
13 ~~which photons are detected to be emitted from at least one~~
14 ~~background data energy channel of said preconcentration cell or~~
15 ~~equivalent cell;~~
16 ~~—— said step of acquiring said sensitivity data comprising the~~
17 ~~steps of:-~~
18 ~~—— filling said preconcentration cell or equivalent cell,~~
19 ~~with a first calibration solution containing at least one element~~
20 ~~of interest in said fluid of interest in known concentration~~
21 ~~above a minimum detection level of x-ray detection equipment to~~
22 ~~be used for said detecting and measuring;~~
23 ~~—— exposing the filled ~~said~~ preconcentration cell or~~
24 ~~equivalent cell to x-rays;—and~~
25 ~~—— acquiring ~~said~~ sensitivity data related to a rate at~~
26 ~~which photons are detected to be emitted from at least one~~
27 ~~sensitivity data energy channel of said preconcentration cell or~~

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28 equivalent cell; and
29 ~~—said step of acquiring said ion extraction rate data~~
30 ~~comprising the steps of:~~
31 ~~—applying said voltage differential across the said~~
32 electrodes of said preconcentration cell or equivalent cell,
33 below an electrochemical potential of said at least one element
34 of interest and below an electrolysis potential of a ~~said~~ second
35 calibration solution;
36 ~~—flowing said a~~ second calibration solution containing
37 said at least one element of interest in said fluid of interest
38 in known concentration below a ~~said~~ minimum detection level of x-
39 ray detection equipment to be used for said detecting and
40 measuring through the ~~said~~ central flow interelectrode gap of
41 said preconcentration cell or equivalent cell, at a substantially
42 constant flow rate;
43 ~~—exposing said preconcentration cell or equivalent cell~~
44 with said second calibration solution therein to x-rays; ~~and~~
45 ~~—acquiring said ion extraction rate data related to a~~
46 rate at which photons are detected to be emitted from ~~said~~ at
47 least one ion extraction rate data energy channel of said
48 preconcentration cell or equivalent cell; and
49 associating said background data, said sensitivity data, and
50 said ion extraction rate data with said preconcentration cell.

1 100. (currently amended) The method of claim 62, further
2 comprising the steps of:
3 applying said voltage differential across said electrodes
4 below an electrochemical potential of said at least one element

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5 of interest and below an electrolysis potential of said fluid,
6 suspected to contain at least one element of interest;
7 flowing said fluid through said central flow interelectrode
8 gap at a substantially constant flow rate;
9 exposing said preconcentration cell with said fluid therein
10 to x-rays; and
11 acquiring said test data related to a rate at which photons
12 are detected to be emitted from at least one test data energy
13 channel of said preconcentration cell.

1 101. (original) The method of claim 100, further comprising
2 the step of:

3 analyzing said test data and deducing therefrom a
4 concentration in said fluid, if any, of the suspected at least
5 one element of interest.

1 102. (currently amended) The method of claim 99, further
2 comprising the steps of:

3 applying said voltage differential across said electrodes
4 below an electrochemical potential of said at least one element
5 of interest and below an electrolysis potential of said fluid,
6 suspected to contain at least one element of interest;
7 flowing said fluid through said central flow interelectrode
8 gap at a substantially constant flow rate;
9 exposing said preconcentration cell with said fluid therein
10 to x-rays; and
11 acquiring said test data related to a rate at which photons
12 are detected to be emitted from at least one test data energy
13 channel of said preconcentration cell.

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1 103. (original) The method of claim 102, further comprising
2 the step of:

3 analyzing said test data in relation to said background
4 data, said sensitivity data, and said ion extraction rate data,
5 and deducing therefrom a concentration in said fluid, if any, of
6 the suspected at least one element of interest.

1 104. (currently amended) The method of claim 62, further
2 comprising the steps of:

3 exposing said preconcentration cell to x-rays substantially
4 transmitted through said upper x-ray transmission window, while
5 flowing said fluid and while applying said voltage differential.

1 105. (currently amended) The method of claim 62, said step of
2 applying said voltage differential further comprising the steps
3 of:

4 ceasing flow of ~~flowing~~ said fluid while applying an
5 electrostatic charge across said electrodes and thereby
6 maintaining ions from said at least one element entrained in said
7 electrodes ~~continuing to apply said voltage differential~~;

8 transporting said ionic preconcentration cell to an x-ray
9 source means for emitting x-rays toward said preconcentration
10 cell while ~~continuing to applying~~ said electrostatic
11 charge ~~voltage differential~~; and

12 exposing said preconcentration cell to x-rays from said x-
13 ray source means while ~~continuing to applying~~ said electrostatic
14 charge ~~voltage differential~~.

1 106. (currently amended) The method of claim 62, further
2 comprising the step of:

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controlling a flow rate of said fluid through said ionic preconcentration cell so as to maintain ε , which designates a predetermined percentage of at least one element of interest to be extracted from said fluid, below approximately 5% for said at least one element of interest.

107. (currently amended) The method of claim 106, further comprising the step of:

maintaining said ε below an extraction percentage selected from ~~an~~ the extraction percentage group consisting of approximately 4%, 3%, 2%, and 1%.

108. (currently amended) The method of claim 62, further comprising the step of:

controlling a flow rate F of said fluid through said ionic preconcentration cell and maintaining said F at a substantially constant level so as to maintain ε , which designates a predetermined percentage of at least one element of interest to be extracted from said fluid and is specified by:

$$\varepsilon = \frac{\Gamma_{ie}}{\Gamma_{is}} = \frac{\sigma \Phi w_i A}{qd w_f n_f CF} \times 100\%,$$

below approximately 5% for said at least one element of interest; wherein:

Γ_{ie} and Γ_{is} designate rates at which ions of said at least one element of interest are respectively extracted from said fluid by said cell and supplied to said cell by said fluid, σ designates a composite conductivity of said fluid, Φ designates said voltage differential applied across said electrodes, d designates said predetermined interelectrode gap width of said

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17 central flow interelectrode gap, $q = 1.60 \times 10^{-19}$ Coulomb designates
18 the unit charge, A designates an ordinary surface area covered by
19 said electrodes, n_f designates a number density of said fluid,
20 w_i and w_f designate atomic / molecular weights, respectively, of
21 said at least one element of interest and of said fluid, and C
22 designates a concentration of said at least one element of
23 interest in said fluid; and

24 having for said concentration C in a range where
25 conductivity varies substantially linearly with concentration,
26 with C in units of parts per billion, wherein σ is approximated
27 by:

28 $\sigma \approx 2 \times 10^{-9} C / \text{Ohm} - \text{cm} .$

1 109. (currently amended) The method of claim 108, further
2 comprising the step of:

3 maintaining said ε below an extraction percentage selected
4 from an ~~the~~ extraction percentage group consisting of
5 approximately 4%, 3%, 2%, and 1%.

1 110. (original) The method of claim 62, further comprising the
2 step of:

3 applying said voltage differential across said electrodes
4 below an electrochemical potential of at least one element of
5 interest and below an electrolysis potential of said fluid.

1 111. (original) The method of claim 62, further comprising the
2 step of:

3 monitoring a total concentration of dissolved ions in said
4 upper and lower high surface area electrodes while said
5 electrodes are not saturated, detecting a saturation state of

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6 | ~~said cell~~ by monitoring a leakage current from said cell.

1 | 112. (original) The method of claim 111, further comprising
2 | the step of:

3 | measuring at least one element of interest comprising ultra-
4 | low trace, high valence ions in said fluid, based on said
5 | detecting said saturation state.

1 | 113. (currently amended) The method of claim 62, further
2 | comprising the steps of:

3 | monitoring a total concentration of dissolved ions in said
4 | upper and lower high surface area electrodes while said
5 | electrodes are not saturated ~~estimating a concentration in said~~
6 | ~~fluid of at least one element of interest by monitoring a leakage~~
7 | ~~current in said cell; and~~

8 | ~~adjusting the flow of~~ controlling how long said fluid flows
9 | through said ionic preconcentration cell to control a percentage
10 | of said ions extracted from said fluid, based on the estimate
11 | ~~obtained by said monitoring said leakage current~~ ~~said leakage~~
12 | ~~current monitoring means.~~

1 | 114. (currently amended) The method of claim ~~62-1~~, further
2 | comprising the steps of:

3 | setting an impurity concentration C , in a range where
4 | conductivity varies substantially linearly with concentration, to
5 | a predetermined desired concentration detection level; and

6 | controlling how long said fluid flows through said ionic
7 | preconcentration cell by flowing said fluid for a time t given
8 | by:

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9 $t \propto \frac{Sl}{\sigma} \propto \frac{Sl}{C}$, wherein:

10 S designates a sensitivity of x-ray detection equipment to
11 be used for said detecting and measuring;

12 ~~LA~~ designates a thickness of said upper high surface area
13 electrode; and

14 σ designates a composite conductivity of said fluid.

1 115. (currently amended) The method of claim 62, further
2 comprising the step of:

3 triggering an action in response to detecting ~~when said~~
4 ~~method detects~~ that a concentration of at least one element of
5 interest in said fluid has passed a predetermined threshold
6 concentration.

1 116. (currently amended) The method of claim 115, said step of
2 triggering further comprising the steps of:

3 maintaining said concentration within a predetermined
4 concentration range by injecting at least one element into said
5 fluid as said action in response to said detecting ~~triggering~~.

1 117. (currently amended) The method of claim 115, said step of
2 triggering further comprising the steps of:

3 maintaining said concentration within a predetermined
4 concentration range by diluting at least one diluting fluid into
5 said fluid as said action in response to said detecting ~~triggering~~.
6 ~~triggering~~.

1 118. (currently amended) The method of claim 62, further
2 comprising the step of:

3 cleaning said preconcentration cell after use by releasing

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4 ~~said~~ ions accumulated within said high specific surface area of
5 said electrodes into said fluid, after the accumulated ions have
6 been exposed to x-rays and fluorescence from said
7 preconcentration cell has been detected.

1 119. (currently amended) The method of claim 64-62, further
2 comprising the steps of:

3 emitting x-rays toward said preconcentration cell_
4 substantially transmitted through said upper x-ray transmission
5 window; and
6 detecting fluoresced energy emitted by said preconcentration
7 cell due to said emitting ~~said~~ x-rays toward said
8 preconcentration cell, through said upper x-ray transmission
9 window.

1 120. (currently amended) The method of claim 119, further
2 comprising the step of:

3 analyzing the detected x-ray fluoresced energy and deducing
4 therefrom a concentration in said fluid of at least one element
5 of interest in said fluid.

1 121. (currently amended) The method of claim 62, further
2 comprising the step of:

3 downloading and analyzing said test data from ~~controlling an~~
4 ~~operation of~~ said ionic preconcentration cell using a
5 telecommunications link.

1 122. (new) The system of claim 3, wherein:

2 said transportable voltage supply is embedded into a body of
3 said ionic preconcentration cell.

1 123. (new) The method of claim 63, further comprising the step

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2 of:

3 providing said transportable voltage supply embedded into a
4 body of said ionic preconcentration cell.

1 124. (new) An ionic preconcentration cell apparatus for
2 identifying and measuring concentrations of elements in fluids,
3 comprising:

4 an upper high surface area electrode comprising a high
5 specific surface area thereof;

6 a lower high surface area electrode comprising a high
7 specific surface area thereof, substantially parallel to said
8 upper high surface area electrode;

9 a central flow interelectrode gap separating said upper and
10 lower high surface area electrodes by a predetermined
11 interelectrode gap width;

12 fluid flow means for flowing a fluid through said central
13 flow interelectrode gap; and

14 an upper x-ray transmission window in intimate contact with
15 an upper surface of said upper high surface area electrode.

1 125. (new) The apparatus of claim 124, further comprising:

2 voltage application means for applying a voltage
3 differential between said upper high surface area electrode and
4 said lower high surface area electrode while said fluid is
5 flowing through said central flow interelectrode gap.

1 126. (new) The apparatus of claim 125, said voltage
2 application means further comprising:

3 a transportable voltage supply connected across said upper
4 and lower high surface area electrodes for applying an

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5 electrostatic charge across said electrodes and thereby
6 maintaining ions from said at least one element entrained in said
7 electrodes during transport of said ionic preconcentration cell.

1 127. (new) The apparatus of claim 126, wherein:

2 said transportable voltage supply is embedded into a body of
3 said ionic preconcentration cell.

1 128. (new) The apparatus of claim 125, said voltage
2 application means further comprising:

3 a transportable voltage supply for applying an electrostatic
4 charge across said electrodes and thereby maintaining ions from
5 said at least one element entrained in said electrodes during
6 transport of said ionic preconcentration cell: after ceasing flow
7 of said fluid, while transporting said ionic preconcentration
8 cell to an x-ray source means for emitting x-rays toward said
9 preconcentration cell, and while exposing said preconcentration
10 cell to x-rays.

11 129. (new) The apparatus of claim 125, further comprising:

2 , x-ray source means positioned and aligned relative to said
3 upper x-ray transmission window for exposing said
4 preconcentration cell to x-rays substantially transmitted through
5 said upper x-ray transmission window, while flowing said fluid
6 and while applying said voltage differential.

1 130. (new) The apparatus of claim 124, further comprising:

2 a lower x-ray transmission window in intimate contact with a
3 lower surface of said lower high surface area electrode.

1 131. (new) The apparatus of claim 124, further comprising:

2 x-ray source means positioned and aligned relative to said

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3 upper x-ray transmission window for emitting x-rays toward said
4 preconcentration cell substantially transmitted through said
5 upper x-ray transmission window.

1 132. (new) The apparatus of claim 131, further comprising:
2 x-ray fluorescence detector means positioned and aligned
3 relative to said upper x-ray transmission window for detecting
4 fluoresced energy emitted by said preconcentration cell due to
5 said emitting x-rays toward said preconcentration cell, through
6 said upper x-ray transmission window.

1 133. (new) The apparatus of claim 132, further comprising:
2 x-ray fluorescence analysis means for analyzing the detected
3 x-ray fluoresced energy and deducing therefrom a concentration in
4 said fluid of at least one element of interest in said fluid.

1 134. (new) The apparatus of claim 124, further comprising:
2 a cell collector body maintaining a position of said upper
3 and lower high surface area electrodes and said upper x-ray
4 transmission window relative to one another, said cell collector
5 body in turn comprising a material comprising:
6 substantially no conductivity;
7 resistance to ionic leaching; and
8 resistance to radiation degradation from x-rays to
9 which said preconcentration cell is to be exposed.

1 135. (new) The apparatus of claim 124, further comprising:
2 a cell collector body maintaining a position of said upper
3 and lower high surface area electrodes and said upper x-ray
4 transmission window relative to one another, said cell collector
5 body comprising a material selected from a material group

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6 consisting of: plastic, glass, and fiberglass.

1 136. (new) The apparatus of claim 124, further comprising:

2 a cell collector body maintaining a position of said upper
3 and lower high surface area electrodes and said upper x-ray
4 transmission window relative to one another, said cell collector
5 body comprising a non-conducting, machinable polymer
6 substantially resistant to radiation degradation.

1 137. (new) The apparatus of claim 124, said upper high surface
2 area electrode and said lower high surface area electrode further
3 comprising an ordinary surface area approximately equal to an
4 interrogation spot area of x-rays to which said preconcentration
5 cell is to be exposed.

1 138. (new) The apparatus of claim 124, said upper x-ray
2 transmission window comprising a surface area approximately equal
3 to an interrogation spot area of x-rays to which said
4 preconcentration cell is to be exposed.

1 139. (new) The apparatus of claim 124, said upper x-ray
2 transmission window comprising:

3 an atomic number below 10;

4 structural rigidity to support up to 1/10 atm. of pressure
5 without bowing more than approximately 100 microns;

6 substantial impermeability relative to said fluid;

7 x-ray transparency greater than 90% for characteristic
8 photon energies from an element of interest for which a fluidic
9 concentration is to be measured;

10 x-ray scattering therefrom minimized to less than

11 approximately 10% of radiation scattered from a column of said

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12 fluid equal to one optical depth in said fluid of a
13 characteristic photonic energy from an element of interest for
14 which a fluidic concentration is to be measured; and
15 freedom from any single contaminant in excess of 1 part per
16 million, when measured by x-ray fluorescence.

1 140. (new) The apparatus of claim 130, said lower x-ray
2 transmission window comprising:
3 an atomic number below 10;
4 structural rigidity to support up to 1/10 atm. of pressure
5 without bowing more than approximately 100 microns;
6 substantial impermeability relative to said fluid;
7 x-ray transparency greater than 90% for characteristic
8 photon energies from an element of interest for which a fluidic
9 concentration is to be measured;
10 x-ray scattering therefrom minimized to less than
11 approximately 10% of radiation scattered from a column of said
12 fluid equal to one optical depth in said fluid of a
13 characteristic photonic energy from an element of interest for
14 which a fluidic concentration is to be measured; and
15 freedom from any single contaminant in excess of 1 part per
16 million, when measured by x-ray fluorescence.

1 141. (new) The apparatus of claim 124, said upper x-ray
2 transmission window comprising a polyimide film comprising
3 structural rigidity to support up to 1/10 atm. of pressure
4 without bowing more than approximately 100 microns.

1 142. (new) The apparatus of claim 130, said lower x-ray
2 transmission window comprising a polyimide film comprising

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3 structural rigidity to support up to 1/10 atm. of pressure
4 without bowing more than approximately 100 microns.

1 143. (new) A method for identifying and measuring
2 concentrations of elements in fluids, comprising the steps of:
3 flowing a fluid through a central flow interelectrode gap of
4 an ionic preconcentration cell separating an upper high specific
5 surface area electrode from a lower high specific surface area
6 electrode of said ionic preconcentration cell by a predetermined
7 interelectrode gap width;
8 applying a voltage differential between said upper high
9 surface area electrode and said lower high surface area electrode
10 while said fluid is flowing through said central flow
11 interelectrode gap;
12 passing x-rays through an upper x-ray transmission window
13 intimately contacting an upper surface of said upper high surface
14 area electrode; and
15 deducing an identity, or measurement of concentration, of at
16 least one element in said fluid based on a response of said
17 preconcentration cell to said x-rays.

1 144. (new) The method of claim 143, said step of applying said
2 voltage differential further comprising the step of:

3 applying an electrostatic charge across said electrodes and
4 thereby maintaining ions from said at least one element entrained
5 in said electrodes during transport of said ionic
6 preconcentration cell, using a transportable voltage supply.

1 145. (new) The method of claim 144, further comprising the
2 step of:

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3 providing said transportable voltage supply embedded into a
4 body of said ionic preconcentration cell.

1 146. (new) The method of claim 143, said step of applying said
2 voltage differential further comprising the steps of:

3 ceasing flow of said fluid while applying an electrostatic
4 charge across said electrodes and thereby maintaining ions from
5 said at least one element entrained in said electrodes;

6 transporting said ionic preconcentration cell to an x-ray
7 source means for emitting x-rays toward said preconcentration
8 cell while applying said electrostatic charge; and

9 exposing said preconcentration cell to x-rays from said x-
10 ray source means while applying said electrostatic charge.

1 147. (new) The method of claim 143, further comprising the
2 steps of:

3 exposing said preconcentration cell to x-rays substantially
4 transmitted through said upper x-ray transmission window, while
5 flowing said fluid and while applying said voltage differential.

1 148. (new) The method of claim 143, further comprising the
2 step of:

3 passing said x-rays through a lower x-ray transmission
4 window intimately contacting a lower surface of said lower high
5 surface area electrode.

1 149. (new) The method of claim 143, further comprising the
2 step of:

3 emitting x-rays toward said preconcentration cell
4 substantially transmitted through said upper x-ray transmission
5 window.

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1 150. (new) The method of claim 149, further comprising the
2 step of:

3 detecting fluoresced energy emitted by said preconcentration
4 cell due to said emitting x-rays toward said preconcentration
5 cell, through said upper x-ray transmission window.

1 151. (new) The method of claim 150, further comprising the
2 step of:

3 analyzing the detected x-ray fluoresced energy and deducing
4 therefrom a concentration in said fluid of at least one element
5 of interest in said fluid.

1 152. (new) The method of claim 143, further comprising the
2 step of:

3 maintaining a position of said upper and lower high surface
4 area electrodes and said upper x-ray transmission window relative
5 to one another, using a body of said ionic preconcentration cell
6 comprising a material comprising:
7 substantially no conductivity;
8 resistance to ionic leaching; and
9 resistance to radiation degradation from x-rays to
10 which said preconcentration cell is to be exposed.

1 153. (new) The method of claim 143, further comprising the
2 step of:

3 maintaining a position of said upper and lower high surface
4 area electrodes and said upper x-ray transmission window relative
5 to one another, using a body of said ionic preconcentration cell
6 comprising a material selected from a material group consisting
7 of: plastic, glass, and fiberglass.

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1 154. (new) The method of claim 143, further comprising the
2 step of:

3 maintaining a position of said upper and lower high surface
4 area electrodes and said upper x-ray transmission window relative
5 to one another, using a body of said ionic preconcentration cell
6 comprising a material comprising a non-conducting, machinable
7 polymer substantially resistant to radiation degradation.

1 155. (new) The method of claim 143, further comprising the
2 step of:

3 providing ordinary surface areas of said upper high surface
4 area electrode and said lower high surface area electrode
5 approximately equal to an interrogation spot area of x-rays to
6 which said preconcentration cell is to be exposed.

1 156. (new) The method of claim 143, further comprising the
2 step of:

3 providing a surface area of said upper x-ray transmission
4 window approximately equal to an interrogation spot area of x-
5 rays to which said preconcentration cell is to be exposed.

1 157. (new) The method of claim 143, further comprising the
2 step of providing said upper x-ray transmission window
3 comprising:

4 an atomic number below 10;

5 structural rigidity to support up to 1/10 atm. of pressure
6 without bowing more than approximately 100 microns;

7 substantial impermeability relative to said fluid;

8 x-ray transparency greater than 90% for characteristic
9 photon energies from an element of interest for which a fluidic

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10 concentration is to be measured by said method;

11 x-ray scattering therefrom minimized to less than
12 approximately 10% of radiation scattered from a column of said
13 fluid equal to one optical depth in said fluid of a
14 characteristic photonic energy from an element of interest for
15 which a fluidic concentration is to be measured by said method;
16 and

17 freedom from any single contaminant in excess of 1 part per
18 million, when measured by x-ray fluorescence.

1 158. (new) The method of claim 148, further comprising the
2 step of providing said lower x-ray transmission window
3 comprising:

4 an atomic number below 10;
5 structural rigidity to support up to 1/10 atm. of pressure
6 without bowing more than approximately 100 microns;
7 substantial impermeability relative to said fluid;
8 x-ray transparency greater than 90% for characteristic
9 photon energies from an element of interest for which a fluidic
10 concentration is to be measured by said method;

11 x-ray scattering therefrom minimized to less than
12 approximately 10% of radiation scattered from a column of said
13 fluid equal to one optical depth in said fluid of a
14 characteristic photonic energy from an element of interest for
15 which a fluidic concentration is to be measured by said method;
16 and

17 freedom from any single contaminant in excess of 1 part per
18 million, when measured by x-ray fluorescence.

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1 159. (new) The method of claim 143, further comprising the
2 step of:

3 providing said upper x-ray transmission window comprising a
4 polyimide film comprising structural rigidity to support up to
5 1/10 atm. of pressure without bowing more than approximately 100
6 microns.

1 160. (new) The method of claim 148, further comprising the
2 step of:

3 providing said lower x-ray transmission window comprising a
4 polyimide film comprising structural rigidity to support up to
5 1/10 atm. of pressure without bowing more than approximately 100
6 microns.

1 161. (new) A method of optimizing fabrication of an ionic
2 preconcentration cell for identifying and measuring
3 concentrations of elements in fluids; said ionic preconcentration
4 cell comprising an upper high surface area electrode comprising a
5 high specific surface area thereof; a lower high surface area
6 electrode comprising a high specific surface area thereof; and a
7 central flow interelectrode gap separating said upper and lower
8 high surface area electrodes by a predetermined interelectrode
9 gap width; said method comprising the step of:

10 optimizing said upper high surface area electrode with an
11 upper electrode thickness less than or equal to approximately an
12 optical depth ℓ of said upper high surface area electrode when
13 wetted with a fluid to be flowed through said cell.

1 162. (new) The optimization method of claim 161, wherein:

2 said $\ell = 1/(\mu * \rho)$;

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3 μ designates a mass absorption coefficient of said upper
4 high surface area electrode when wetted with said fluid; and
5 ρ designates a material density of said upper high surface
6 area electrode when wetted with said fluid.

1 163. (new) The optimization method of claim 161, further
2 comprising the step of:

3 optimizing said lower high surface area electrode with a
4 lower electrode thickness less than or equal to approximately an
5 optical depth ℓ of said lower high surface area electrode when
6 wetted with said fluid.

1 164. (new) The optimization method of claim 163, wherein:

2 said $\ell = 1/(\mu * \rho)$;

3 μ designates a mass absorption coefficient of said lower
4 high surface area electrode when wetted with said fluid; and.

5 ρ designates a material density of said lower high surface
6 area electrode when wetted with said fluid.

1 165. (new) A method of optimizing fabrication of an ionic
2 preconcentration cell for identifying and measuring
3 concentrations of elements in fluids; said ionic preconcentration
4 cell comprising an upper high surface area electrode comprising a
5 high specific surface area thereof; a lower high surface area
6 electrode comprising a high specific surface area thereof; and a
7 central flow interelectrode gap separating said upper and lower
8 high surface area electrodes by a predetermined interelectrode
9 gap width; said method comprising the step of:
10 optimizing said upper high surface area electrode with an

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11 upper electrode thickness less than or equal to approximately an
12 optical depth ℓ of said upper high surface area electrode when
13 wetted with an element of interest for which a fluidic
14 concentration is to be measured by said cell, in a fluid to be
15 flowed through said cell.

1 166. (new) The optimization method of claim 165, wherein:

2 said $\ell = 1/(\mu * \rho)$;

3 μ designates a mass absorption coefficient of said upper
4 high surface area electrode when wetted with said element of
5 interest in said fluid; and

6 ρ designates a material density of said upper high surface
7 area electrode when wetted with said element of interest in said
8 fluid.

1 167. (new) The optimization method of claim 165, further
2 comprising the step of:

3 optimizing said lower high surface area electrode with a
4 lower electrode thickness less than or equal to approximately an
5 optical depth ℓ of said lower high surface area electrode when
6 wetted with said element of interest, in said fluid.

1 168. (new) The optimization method of claim 167, wherein:

2 said $\ell = 1/(\mu * \rho)$;

3 μ designates a mass absorption coefficient of said lower
4 high surface area electrode when wetted with said element of
5 interest in said fluid; and

6 ρ designates a material density of said lower high surface
7 area electrode when wetted with said element of interest in said

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8 fluid.

1 169. (new) An optimized ionic preconcentration cell product,
2 optimized for identifying and measuring concentrations of
3 elements in fluids; said ionic preconcentration cell comprising
4 an upper high surface area electrode comprising a high specific
5 surface area thereof; a lower high surface area electrode
6 comprising a high specific surface area thereof; and a central
7 flow interelectrode gap separating said upper and lower high
8 surface area electrodes by a predetermined interelectrode gap
9 width; produced by a process comprising the step of:
10 optimizing said upper high surface area electrode with an
11 upper electrode thickness less than or equal to approximately an
12 optical depth ℓ of said upper high surface area electrode when
13 wetted with a fluid to be flowed through said cell.

1 170. (new) The optimized product-by-process of claim 169,
2 wherein:

3 said $\ell = 1/(\mu * \rho)$;

4 μ designates a mass absorption coefficient of said upper
5 high surface area electrode when wetted with said fluid; and
6 ρ designates a material density of said upper high surface
7 area electrode when wetted with said fluid.

1 171. (new) The optimized product-by-process of claim 169,
2 further comprising the step of:

3 optimizing said lower high surface area electrode with a
4 lower electrode thickness less than or equal to approximately an
5 optical depth ℓ of said lower high surface area electrode when

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6 wetted with said fluid.

1 172. (new) The optimized product-by-process of claim 171,
2 wherein:

3 said $\ell = 1/(\mu * p)$;

4 μ designates a mass absorption coefficient of said lower
5 high surface area electrode when wetted with said fluid; and

6 p designates a material density of said lower high surface
7 area electrode when wetted with said fluid.

1 173. (new) An optimized ionic preconcentration cell product,
2 optimized for identifying and measuring concentrations of
3 elements in fluids; said ionic preconcentration cell comprising
4 an upper high surface area electrode comprising a high specific
5 surface area thereof; a lower high surface area electrode
6 comprising a high specific surface area thereof; and a central
7 flow interelectrode gap separating said upper and lower high
8 surface area electrodes by a predetermined interelectrode gap
9 width; produced by a process comprising the step of:

10 optimizing said upper high surface area electrode with an
11 upper electrode thickness less than or equal to approximately an
12 optical depth ℓ of said upper high surface area electrode when
13 wetted with an element of interest for which a fluidic
14 concentration is to be measured by said cell, in a fluid to be
15 flowed through said cell.

1 174. (new) The optimized product-by-process of claim 173,
2 wherein:

3 said $\ell = 1/(\mu * p)$;

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4 μ designates a mass absorption coefficient of said upper
5 high surface area electrode when wetted with said element of
6 interest in said fluid; and

7 ρ designates a material density of said upper high surface
8 area electrode when wetted with said element of interest in said
9 fluid.

1 175. (new) The optimized product-by-process of claim 173,
2 further comprising the step of:

3 optimizing said lower high surface area electrode with a
4 lower electrode thickness less than or equal to approximately an
5 optical depth ℓ of said lower high surface area electrode when
6 wetted with said element of interest, in said fluid.

1 176. (new) The optimized product-by-process of claim 175,
2 wherein:

3 said $\ell = 1/(\mu * \rho)$;

4 μ designates a mass absorption coefficient of said lower
5 high surface area electrode when wetted with said element of
6 interest in said fluid; and

7 ρ designates a material density of said lower high surface
8 area electrode when wetted with said element of interest in said
9 fluid.

1 177. (new) A method of optimizing fabrication of an ionic
2 preconcentration cell for identifying and measuring
3 concentrations of elements in fluids; said ionic preconcentration
4 cell comprising an upper high surface area electrode comprising a
5 high specific surface area thereof; a lower high surface area

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electrode comprising a high specific surface area thereof; and a central flow interelectrode gap separating said upper and lower high surface area electrodes by a predetermined interelectrode gap width; said method comprising the step of:

optimizing said central flow interelectrode gap comprising said predetermined interelectrode gap width, designated d , within an interelectrode gap range specified by:

$$d = \frac{\sigma \Phi w_i}{q \epsilon w_f n_f C F} \times 100\% \approx 2 \times 10^{-9} \frac{\Phi w_i A}{q \epsilon w_f n_f F} \times 100\% \propto \frac{\Phi A}{\epsilon F}; \text{ wherein:}$$

ϵ designates a predetermined percentage of at least one element of interest to be extracted from a fluid to be flowed through said cell, σ designates a composite conductivity of said fluid, Φ designates said voltage differential applied across said electrodes, $q = 1.60 \times 10^{-19}$ Coulomb designates the unit charge, A designates an ordinary surface area covered by said electrodes, n_f designates a number density of said fluid, w_i and w_f designate atomic / molecular weights, respectively, of said at least one element of interest and of said fluid, C designates a concentration of said at least one element of interest in said fluid, and F designates a flow rate of said fluid through said ionic preconcentration cell;

said high surface area electrodes further comprise said ordinary surface area A approximately equal to an interrogation spot area of x-rays to which said preconcentration cell is to be exposed;

said ϵ is chosen to be below approximately 5% for said at least one element of interest;

32 said Φ is chosen to be below an electrochemical potential of
33 said at least one element of interest and below an electrolysis
34 potential of said fluid;

35 said F is chosen to exert no more than approximately .1 atm
36 of pressure upon an upper x-ray transmission window of said ionic
37 preconcentration cell in intimate contact with an upper surface
38 of said upper high surface area electrode;

39 said n_f and said w_f are chosen with reference to said at
40 least one element of interest; and

41 said w_i is chosen with reference to said fluid.

1 178. (new) The optimization method of claim 177, wherein:

2 as a consequence of said optimizing, said central flow
3 interelectrode gap comprises said predetermined interelectrode
4 gap width, d , with:

5 a minimum gap width selected from a minimum gap width group
6 consisting of 2 mm, 1 mm, .5 mm, and .25 mm; and

7 a maximum gap width selected from a maximum gap width group
8 consisting of 2 mm, 5 mm, and 10 mm.

1 179. (new) An optimized ionic preconcentration cell product,
2 optimized for identifying and measuring concentrations of
3 elements in fluids; said ionic preconcentration cell comprising
4 an upper high surface area electrode comprising a high specific
5 surface area thereof; a lower high surface area electrode
6 comprising a high specific surface area thereof; and a central
7 flow interelectrode gap separating said upper and lower high
8 surface area electrodes by a predetermined interelectrode gap
9 width; produced by a process comprising the step of:

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10 optimizing said central flow interelectrode gap comprising
 11 said predetermined interelectrode gap width, designated d , within
 12 an interelectrode gap range specified by:

$$13 \quad d = \frac{\sigma \Phi w_i}{q \varepsilon w_f n_f C F} \times 100\% \approx 2 \times 10^{-9} \frac{\Phi w_i A}{q \varepsilon w_f n_f F} \times 100\% \propto \frac{\Phi A}{\varepsilon F}; \text{ wherein:}$$

14 ε designates a predetermined percentage of at least one
 15 element of interest to be extracted from a fluid to be flowed
 16 through said cell, σ designates a composite conductivity of said
 17 fluid, Φ designates said voltage differential applied across
 18 said electrodes, $q = 1.60 \times 10^{-19}$ Coulomb designates the unit
 19 charge, A designates an ordinary surface area covered by said
 20 electrodes, n_f designates a number density of said fluid, w_i and
 21 w_f designate atomic / molecular weights, respectively, of said at
 22 least one element of interest and of said fluid, C designates a
 23 concentration of said at least one element of interest in said
 24 fluid, and F designates a flow rate of said fluid through said
 25 ionic preconcentration cell;

26 said high surface area electrodes further comprise said
 27 ordinary surface area A approximately equal to an interrogation
 28 spot area of x-rays to which said preconcentration cell is to be
 29 exposed;

30 said ε is chosen to be below approximately 5% for said at
 31 least one element of interest;

32 said Φ is chosen to be below an electrochemical potential of
 33 said at least one element of interest and below an electrolysis
 34 potential of said fluid;

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35 said F is chosen to exert no more than approximately .1 atm
36 of pressure upon an upper x-ray transmission window of said ionic
37 preconcentration cell in intimate contact with an upper surface
38 of said upper high surface area electrode;

39 said n_f and said w_f are chosen with reference to said at
40 least one element of interest; and

41 said w_i is chosen with reference to said fluid.

1 180. (new) The optimized product-by-process of claim 179,
2 wherein:

3 as a consequence of said optimizing, said central flow
4 interelectrode gap comprises said predetermined interelectrode
5 gap width, d , with:

6 a minimum gap width selected from a minimum gap width group
7 consisting of 2 mm, 1 mm, .5 mm, and .25 mm; and

8 a maximum gap width selected from a maximum gap width group
9 consisting of 2 mm, 5 mm, and 10 mm.

1 181. (new) An ionic preconcentration cell apparatus for
2 identifying and measuring concentrations of elements in fluids,
3 comprising:

4 an upper high surface area electrode comprising a high
5 specific surface area thereof;

6 a lower high surface area electrode comprising a high
7 specific surface area thereof, substantially parallel to said
8 upper high surface area electrode;

9 a central flow interelectrode gap separating said upper and
10 lower high surface area electrodes by a predetermined
11 interelectrode gap width;

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12 fluid flow means for flowing a fluid through said central
13 flow interelectrode gap; and
14 said upper high surface area electrode and said lower high
15 surface area electrode each comprising a high surface area
16 material in turn comprising an x-ray transparency greater than
17 approximately 90% for characteristic photon energies from an
18 element of interest for which a fluidic concentration is to be
19 measured.

1 182. (new) The apparatus of 181, said high surface area
2 material further comprising:
3 a large plurality of pores characterized by a specific
4 surface area of at least approximately 100 m²/g;
5 an average pore diameter of said pores between approximately
6 30 nm and 10 nm per pore.

1 183. (new) The apparatus of 181, said high surface area
2 material further comprising:
3 the ability to contain approximately at least 0.1% by weight
4 of foreign material relative to said high surface area material
5 prior to saturation.

1 184. (new) The apparatus of 181, said high surface area
2 material further comprising:
3 high structural rigidity wherein a displacement under the
4 flow of said fluid does not exceed approximately 0.25mm.

1 185. (new) The apparatus of 181, said high surface area
2 material further comprising:
3 freedom from metallic impurities in excess of approximately
4 .5 parts per million, when measured by x-ray fluorescence

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5 analysis.

1 186. (new) A method for identifying and measuring
2 concentrations of elements in fluids, comprising the steps of:
3 flowing a fluid through a central flow interelectrode gap of
4 an ionic preconcentration cell separating an upper high specific
5 surface area electrode from a lower high specific surface area
6 electrode of said ionic preconcentration cell by a predetermined
7 interelectrode gap width;
8 applying a voltage differential between said upper high
9 surface area electrode and said lower high surface area electrode
10 while said fluid is flowing through said central flow
11 interelectrode gap;
12 exposing said cell to x-rays;
13 deducing an identity, or measurement of concentration, of at
14 least one element in said fluid based on a response of said
15 preconcentration cell to said x-rays; and
16 providing said upper high surface area electrode and said
17 lower high surface area electrode each comprising a high surface
18 area material in turn comprising an x-ray transparency greater
19 than approximately 90% for characteristic photon energies from an
20 element of interest for which a fluidic concentration is to be
21 measured.

1 187. (new) The method of claim 186, further comprising the
2 step of providing said high surface area material further
3 comprising:
4 a large plurality of pores characterized by a specific
5 surface area of at least approximately 100 m²/g;

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6 an average pore diameter of said pores between approximately
7 30 nm and 10 nm per pore.

1 188. (new) The method of claim 186, further comprising the
2 step of providing said high surface area material further
3 comprising:

4 the ability to contain approximately at least 0.1% by weight
5 of foreign material relative to said high surface area material
6 prior to saturation.

1 189. (new) The method of claim 186, further comprising the
2 step of providing said high surface area material further
3 comprising:

4 high structural rigidity wherein a displacement under the
5 flow of said fluid does not exceed approximately 0.25mm.

1 190. (new) The method of claim 186, further comprising the
2 step of providing said high surface area material further
3 comprising:

4 freedom from metallic impurities in excess of approximately
5 .5 parts per million, when measured by x-ray fluorescence
6 analysis.

1 191. (new) An ionic preconcentration cell apparatus for
2 identifying and measuring concentrations of elements in fluids,
3 comprising:

4 an upper high surface area electrode comprising a high
5 specific surface area thereof;

6 a lower high surface area electrode comprising a high
7 specific surface area thereof, substantially parallel to said
8 upper high surface area electrode;

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9 a central flow interelectrode gap separating said upper and
 10 lower high surface area electrodes by a predetermined
 11 interelectrode gap width;

12 fluid flow means for flowing a fluid through said central
 13 flow interelectrode gap; and

14 flow control means for controlling a flow rate of said fluid
 15 through said ionic preconcentration cell so as to maintain ε ,
 16 which designates a predetermined percentage of at least one
 17 element of interest to be extracted from said fluid, below
 18 approximately 5% for said at least one element of interest.

1 192. (new) The apparatus of claim 191, wherein said ε is
 2 maintained below an extraction percentage selected from an
 3 extraction percentage group consisting of approximately 4%, 3%,
 4 2%, and 1%.

1 193. (new) The apparatus of claim 191, further comprising:

2 voltage application means for applying a voltage
 3 differential between said upper high surface area electrode and
 4 said lower high surface area electrode while said fluid is
 5 flowing through said central flow interelectrode gap; and

6 said flow control means for controlling said flow rate F of
 7 said fluid through said ionic preconcentration cell and
 8 maintaining said F at a substantially constant level so as to
 9 maintain said ε , which is specified by:

$$10 \quad \varepsilon = \frac{\Gamma_{ie}}{\Gamma_{is}} = \frac{\sigma \Phi w_i}{qd w_f n_f CF} \times 100\%,$$

11 below approximately 5% for said at least one element of interest;
 12 wherein:

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13 Γ_{ie} and Γ_{is} designate rates at which ions of said at least
14 one element of interest are respectively extracted from said
15 fluid by said cell and supplied to said cell by said fluid, σ
16 designates a composite conductivity of said fluid, Φ designates
17 a potential applied by said voltage application means across said
18 electrodes, d designates said predetermined interelectrode gap
19 width of said central flow interelectrode gap, $q = 1.60 \times 10^{-19}$
20 Coulomb designates the unit charge, A designates an ordinary
21 surface area covered by said electrodes, n_f designates a number
22 density of said fluid, w_i and w_f designate atomic / molecular
23 weights, respectively, of said at least one element of interest
24 and of said fluid, and C designates a concentration of said at
25 least one element of interest in said fluid; and

26 for having said concentration C in a range where
27 conductivity varies substantially linearly with concentration,
28 with C in units of parts per billion, wherein σ is approximated
29 by:

30
$$\sigma \approx 2 \times 10^{-9} C / \text{Ohm} - \text{cm} .$$

1 194. (new) The apparatus of claim 193, wherein said ε is
2 maintained below an extraction percentage selected from the
3 extraction percentage group consisting of approximately 4%, 3%,
4 2% and 1%.

1 195. (new) A method for identifying and measuring
2 concentrations of elements in fluids, comprising the steps of:
3 flowing a fluid through a central flow interelectrode gap of
4 an ionic preconcentration cell separating an upper high specific

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5 surface area electrode from a lower high specific surface area
6 electrode of said ionic preconcentration cell by a predetermined
7 interelectrode gap width;
8 applying a voltage differential between said upper high
9 surface area electrode and said lower high surface area electrode
10 while said fluid is flowing through said central flow
11 interelectrode gap;
12 exposing said cell to x-rays;
13 deducing an identity, or measurement of concentration, of at
14 least one element in said fluid based on a response of said
15 preconcentration cell to said x-rays; and
16 controlling a flow rate of said fluid through said ionic
17 preconcentration cell so as to maintain ε , which designates a
18 predetermined percentage of at least one element of interest to
19 be extracted from said fluid, below approximately 5% for said at
20 least one element of interest.

1 196. (new) The method of claim 195, further comprising the
2 step of:

3 maintaining said ε below an extraction percentage selected
4 from an extraction percentage group consisting of approximately
5 4%, 3%, 2%, and 1%.

1 197. (new) The method of claim 195, said step of controlling
2 said flow rate further comprising the step of:

3 controlling said flow rate F of said fluid through said
4 ionic preconcentration cell and maintaining said F at a
5 substantially constant level so as to maintain said ε , which is
6 specified by:

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$$\varepsilon = \frac{\Gamma_{ie}}{\Gamma_{is}} = \frac{\sigma \Phi w_i}{qd w_f n_f C F} \times 100\%,$$

below approximately 5% for said at least one element of interest;
wherein:

Γ_{ie} and Γ_{is} designate rates at which ions of said at least one element of interest are respectively extracted from said fluid by said cell and supplied to said cell by said fluid, σ designates a composite conductivity of said fluid, Φ designates said voltage differential applied across said electrodes, d designates said predetermined interelectrode gap width of said central flow interelectrode gap, $q = 1.60 \times 10^{-19}$ Coulomb designates the unit charge, A designates an ordinary surface area covered by said electrodes, n_f designates a number density of said fluid, w_i and w_f designate atomic / molecular weights, respectively, of said at least one element of interest and of said fluid, and C designates a concentration of said at least one element of interest in said fluid; and

having said concentration C in a range where conductivity varies substantially linearly with concentration, with C in units of parts per billion, wherein σ is approximated by:

$$\sigma \approx 2 \times 10^{-9} C / \text{Ohm} - \text{cm}.$$

198. (new) The method of claim 197, further comprising the step of:

maintaining said ε below an extraction percentage selected from an extraction percentage group consisting of approximately 4%, 3%, 2%, and 1%.

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1 199. (new) An ionic preconcentration cell apparatus for
2 identifying and measuring concentrations of elements in fluids,
3 comprising:

4 an upper high surface area electrode comprising a high
5 specific surface area thereof;

6 a lower high surface area electrode comprising a high
7 specific surface area thereof, substantially parallel to said
8 upper high surface area electrode;

9 a central flow interelectrode gap separating said upper and
10 lower high surface area electrodes by a predetermined
11 interelectrode gap width;

12 fluid flow means for flowing a fluid through said central
13 flow interelectrode gap; and

14 time control means for controlling how long said fluid flows
15 through said ionic preconcentration cell based on setting an
16 impurity concentration C , in a range where conductivity varies
17 substantially linearly with concentration, to a predetermined
18 desired concentration detection level and flowing said fluid for
19 a time t given by:

20
$$t \propto \frac{S\ell}{\sigma} \propto \frac{S\ell}{C}; \text{ wherein:}$$

21 S designates a sensitivity of x-ray detection equipment to
22 be used for said detecting and measuring;

23 ℓ designates a thickness of said upper high surface area
24 electrode; and

25 σ designates a composite conductivity of said fluid.

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1 200. (new) A method for identifying and measuring
2 concentrations of elements in fluids, comprising the steps of:
3 flowing a fluid through a central flow interelectrode gap of
4 an ionic preconcentration cell separating an upper high specific
5 surface area electrode from a lower high specific surface area
6 electrode of said ionic preconcentration cell by a predetermined
7 interelectrode gap width;
8 applying a voltage differential between said upper high
9 surface area electrode and said lower high surface area electrode
10 while said fluid is flowing through said central flow
11 interelectrode gap;
12 exposing said cell to x-rays;
13 deducing an identity, or measurement of concentration, of at
14 least one element in said fluid based on a response of said
15 preconcentration cell to said x-rays;
16 setting an impurity concentration C , in a range where
17 conductivity varies substantially linearly with concentration, to
18 a predetermined desired concentration detection level; and
19 controlling how long said fluid flows through said ionic
20 preconcentration cell by flowing said fluid for a time t given
21 by:
22 $t \propto \frac{Sl}{\sigma} \propto \frac{Sl}{C}$, wherein:
23 S designates a sensitivity of x-ray detection equipment to
24 be used for said detecting and measuring;
25 l designates a thickness of said upper high surface area
26 electrode; and

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27 σ designates a composite conductivity of said fluid.

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